IN THE SPECIFICATION:

Please amend paragraphs [001], [002], [004], [007], [015], [016], [019], [031], [032], [035], [036], [045], [051], [052], [054], [063], [068], [069], [072], [073], [075] and [080] of the specification as shown below, in which deleted terms are shown with strikethrough and added terms are shown with underscoring.

Paragraph [001]

1. Field of the Invention

The present invention relates to a vehicle speed measuring apparatus for measuring ~~vehicle~~ speed of a vehicle.

Paragraph [002]

2. Discussion of Background Art

Vehicle speed is utilized for various controls of a vehicle. Generally, vehicle speed is measured by calculating detection values from wheel speed sensors. For example, in an antilock braking system which prevents wheel lock-up during braking or a vehicle behavior control apparatus, vehicle speed is measured by calculating detection values detected by wheel speed sensors. Japanese Laid-open Patent Application No.2001-47998 (claims 2 and 3, columns 0031 and 0032, FIG. 5, etc.) discloses that vehicle speed is obtained by selecting the fastest wheel speed of four wheel speeds detected from the respective wheel sensors or by calculating the average wheel speed of the driven wheels.

Paragraph [004]

With the foregoing drawback of the ~~prior~~ art in view, the present invention mainly seeks to provide a vehicle speed measuring apparatus which can measure vehicle speed without being affected by a change in the tire diameter.

Paragraph [007]

The aforementioned vehicle speed measuring apparatus calculates vehicle speed in consideration of time required for a certain length of object (vehicle body) to pass over a point (a bump, etc.) on the road. In principle, this is different from the ~~prior~~ background art apparatus in which vehicle speed is calculated in consideration of the number of rotations of the tire per a certain length of time. Therefore, the vehicle speed measuring apparatus according to the present invention can measure vehicle speed without (substantially) being affected by a change in the tire diameter.

Paragraph [015]

FIGS. 3(a) – 4(c) explains variations of detection values detected by wheel speed sensors;

Paragraph [016]

FIGS. 4(a) – 4(c) schematically explains the manner of measuring vehicle speed, wherein (a) illustrates an instance where the vehicle runs on a road including points a and b toward the point b, (b) illustrates in time sequence a change in detection values of the respective front and rear wheel speeds in the instance of (a), and (c) illustrates in time sequence changes in the detection values after being processed by digital filters;

Paragraph [019]

FIGS. 7(a), 7(b) schematically shows array variables, wherein (a) shows array variables Vf(n) to which a normalization process has been applied, and (b) shows array variables Vf(m) to which the normalization process has been applied.

Paragraph [031]

Because tires are produced by winding rubber, steal wires, etc., non-uniformity (lack of uniformity) exists on strength or density during one rotation of the tire. As best seen in FIG. 3 (a), when wheel~~s~~ W rotates on the road surface, even if the vehicle C runs at a certain speed, a large variation occurs in time variations of detection values V (variation curve of wheel speed detection values) obtained by the wheel speed sensor VS (see FIG. 3(b)) due to unbalance of the tire (lack of uniformity). A variation with a short period that is derived from a road bump, etc., is

superposed on this variation with a long period. Because the purpose of the present invention is to obtain an absolute vehicle speed from a wheel speed variation due to a road bump, etc., as shown in FIG. 3(c), the vehicle speed measuring apparatus 1 excludes a variation component resulting from the lack of uniformity of the tire by means of the digital filter 12 (i.e., excluding inherent tire influences on the detection values) to smoothly execute subsequent processes. As the wheel speed becomes faster, the period (frequency) of the wheel speed variation derived from the lack of uniformity of the tire and the period (frequency) of the wheel speed variation derived from the road bump, etc. become short as a whole (shift to higher frequency band). Therefore, the digital filter 12 is constructed such that as the wheel speed increases the wheel speed variation at higher frequency band passes through the digital filter 12.

Paragraph [032]

The buffer controller 13 (13f, 13r) functions to obtain, at every 10 milliseconds, a detection value V (Vf, Vr) of the wheel speed that has passed through the digital filter 12 and to write a predetermined number of detection values in the data buffer 14 (14f, 14r). Further, the buffer controller 13 functions to read out the predetermined number of detection values from the data buffer 14.

Paragraph [035]

The predetermined number (final value N) is 16 (final value N=16) for the front wheel side buffer controller 13f. Meanwhile, the predetermined number (final value M) is 30 (final value M=30) for the rear wheel side buffer controller 13r. The reason for restricting the number of data to be stored in the data buffers 14f, 14r is to release a load required for the calculation process at the normalization means 15 or at the cross-correlation function calculation means 16. Also, even if the number of data is restricted, absolute vehicle speed Vv can be measured in a reliable manner. Although the initial value of each process counter n, m is 0, the process counter n, m actually counts the number starting from 1. Therefore, the process counter n takes a positive number substantially from 1 to 16, and the process counter m takes a positive number substantially from 1 to 30. The rear wheel side process counter m takes the final value M that is

greater than the final value N of the front wheel side process counter n. This is because a change ~~appeared~~ appearing at the front wheel side, such as a change of the detection value V upon passing over a bump, occurs at the rear wheel side with a certain time interval. In order to reliably store and detect the same change ~~appeared~~ appearing at the rear wheel side, a sufficient number is set as the final value M.

Paragraph [036]

In this preferred embodiment, the data buffer 14 receives the detection value V from the digital filter 12 at every 10 milliseconds. In this instance, if the detection value Vf is repeatedly stored in the array variable Vf(n) until the process counter n counts the final value of 16, the data buffer 14f stores detection values Vf corresponding to the actual time of 150 milliseconds (150 milliseconds = (16-1) x 10 milliseconds). Likewise, if the detection value Vr is repeatedly stored in the array variable Vr(m) until the process counter m counts the final value of 30, the data buffer 14r stores detection values Vr corresponding to the actual time of 290 milliseconds (290 milliseconds = (30-1) x 10 milliseconds).

Paragraph [045]

The cross-correlation function calculation means 16 calculates (executes) cross-correlation functions in a sort of Fourier transformation. Specifically, the cross-correlation function calculation means 16 processes to determine how (at which point) the change pattern derived from the road bump, etc. that ~~is~~ has appeared at the front wheel Wf within 150 milliseconds appears at the rear wheel Wr within 290 milliseconds. Therefore, the cross-correlation function calculation means 16 receives the whole array variables Vf(n), Vr(m) that have been normalized by the normalization means 15 (15f, 15r), and executes the convolution shown by the following equations (5) through (19) (equations (8) to (18) are omitted).

$$S(1) = Vf(1)\cdot Vr(1) + Vf(2)\cdot Vr(2) + \ldots\ldots + Vf(16)\cdot Vr(16) \qquad (5)$$

$$S(2) = Vf(1)\cdot Vr(2) + Vf(2)\cdot Vr(3) + \ldots\ldots + Vf(16)\cdot Vr(17) \qquad (6)$$

$$S(3) = Vf(1)\cdot Vr(3) + Vf(2)\cdot Vr(4) + \ldots\ldots + Vf(16)\cdot Vr(18) \qquad (7)$$

… … … … … … …

$$S(15) = Vf(1) \cdot Vr(15) + Vf(2) \cdot Vr(16) + ... + Vf(16) \cdot Vr(30) \qquad (19)$$

Paragraph [051]

The time difference Δt corresponds to the term "time difference from a coincidence of the change patterns". The value "10" ~~appeared~~ appearing in the equation (21) indicates the sampling interval for each detection value Vf, Vr. The reason for subtracting 1 from the index j is to obtain the interval number.

Paragraph [052]

The average vehicle speed calculation means 19 processes to calculate the average vehicle speed AVv from the vehicle speed ~~vv~~ Vv that is calculated by the vehicle speed calculation means 18. The average vehicle speed calculation means 19 includes ~~non-illustrated~~ FIFO (First In First Out) shown in Fig. 6. FIFO is a memory to carry out a first-in first-out operation. FIFO stores values of the vehicle speed Vv that ~~has~~ have been calculated by the vehicle speed calculation means 18 and the number of which is K, as the array variable Vv(k). FIFO in order deletes the oldest array variable Vv(K) whenever vehicle speed Vv from the vehicle speed calculation means 18 is stored into FIFO, and increases 1 for the indexes k of the other array variables Vv(k), so that the array variable Vv(1) becomes the array variable Vv(2) and the array variable Vv(K-1) becomes the array variable Vv(K). Values of the vehicle speed Vv over a certain past period of time are in order renewed accordingly. Relation between the index k and its final value K is given by $1 \le k \le K$ (herein, $K > 1$). The final value K is, for example, 5.

Paragraph [054]

If the final value K of the index k is 5, because the final value M of the process counter m is 30 and the data interval of each detection value V (Vf, Vr) is 10 milliseconds, the average vehicle speed AVv is obtained by averaging vehicle speed of the vehicle C for 1.5 seconds (= 30 x 10 milliseconds x 5). As previously described, the buffer controller 13 (13f, 13r) receives the detection value V (Vf, Vr) from the digital filter 12 at every 10 milliseconds, and stores it into the data buffer 14 (14f, 14r).

Paragraph [063]

As seen in FIG. 5, the process counters n, m are initially set to zero. Upon storing the detection values V (Vf, Vr) into the data buffers 14f, 14r, the process counters n, m increase the number of processes. Specifically, the process counter n provided at the front wheel side increases the number of processes (S11). Then, the detection value Vf, to which the digital filter 12f has applied the process, is transmitted at every 10 milliseconds and stored in the data buffer ~~14r~~ 14f as the array variable Vf(n) (S12). Similar processes are carried out at the rear wheel side, wherein steps S13, S14 correspond to steps S11, S12, respectively.

Paragraph [068]

As a result, 16 detection values Vf are stored in order at every 10 milliseconds as the array variables Vf(n), and 30 detection values Vr are stored in order as the array variables Vr(m). Therefore, the preparation for the subsequent process (calculation process for the average vehicle speed) is completed.

Paragraph [069]

CALCULATING AVERAGE VEHICLE SPEED

When the certain number of array variables Vf(n), Vr(m) are stored in the data buffers 14f, 14r, as shown in the flow chart of FIG. 6, all the array variables Vf(n), Vr(m) are read out from the data buffers (S21). The normalization is then carried out for the front and rear wheel sides according to the previously described processes (S22, S23). During the normalization the equations (1) to (4) are used for calculations. BY the result of the normalization, the array variables Vf(n), Vr(m) are schematically shown, for example, by the graphs of FIGS. 7(a), 7(b). As previously described, in order to save the memory, the same variable identifiers are utilized before and after the normalization.

Paragraph [072]

In step S26, the maximum value is extracted from the array variable S(j) according to the

equation (20) (S26). Thereafter, the index j of the maximum value S(j) is specified, and the time difference Δt is determined by way of substituting the index into the equation (21). The thus obtained time difference Δt and the wheel base WB that is previously stored in the vehicle speed measuring apparatus 1 are substituted into the equation (22) to calculate the vehicle speed Vv (S27). Herein, the calculation of the cross-correlation functions in step S24 and the extraction of the maximum value in step S26 are corresponding to a trial (i.e., pattern matching) for overlapping the two graphs (a) and (b) shown in FIGS. 7(a, 7(b), and the determination of the time difference Δt in step S27 ~~is corresponding~~ corresponds to determining a phase difference between coincidence points of the two graphs.

Paragraph [073]

Determination of the phase difference will be additionally described with reference to FIGS. 7(a), 7(b) and the equations (5) to (19).

Paragraph [075]

Also in the equation (6) where the phases are not overlapped in conformity, the sum S(2) of the variables is calculated by adding positive values and negative values (see FIGS. 7(a) and 7(b) ~~of FIG. 7~~).

Paragraph [080]

The vehicle speed Vv calculated in step S27 is used to calculate the average vehicle speed AVv in step S28. To be more specific, when the vehicle speed Vv is calculated in step ~~S28~~ S27, the vehicle speed Vv is stored in FIFO (First In First Out memory) as an array variable Vv(k). The average vehicle speed AVv is then calculated by the equation (23) (calculation for the moving average). After the calculation, operation proceeds to RETURN for the continued processes. Step S21 through step S28 are thereby repeated in order and the average vehicle speed AVv is calculated. Because FIFO initially stores no data in step S28, the average vehicle speed AVv is calculated in step S28 (by the average vehicle speed calculation means 19) in accordance with the data stored in FIFO. After all the data are stored in FIFO, the certain number of

detection values Vf, Vr are stored in the data buffers 14f, 14r. All of these detection values Vf, Vr are then read out (S21), and the processes in steps S22 to S28 are executed to immediately calculate the average vehicle speed AVv.